# Liquid immiscibility in the IIAB iron meteorite parent body

Finn Ulff-Møller, Institute of Geophysics and Planetary Physics, University of California, Los Angeles, CA 90095-1567, E-mail: finnulff@cosmic.igpp.ucla.edu

Group IIAB iron meteorites define almost linear trends when Ni, Ir, Au, P, and a number of other trace elements are plotted against each other on a logarithmic scale. These elemental variations are characteristic of the magmatic iron meteorite groups which are generally agreed to have crystallized in the core of differentiated parent bodies. At variance with the observed trends, fractional crystallization models using experimentally determined distribution coefficients [1-3] typically predict curved trends. Immiscibility between a sulfide liquid and a P-rich metal liquid can have a drastic effect on trace element fractionation and is capable of producing trends which are linear within analytical precision [4-5]. The crucial elements which control liquid immiscibility are S and P [6]; the liquid immiscibility field occupies about 70% of that part of the Fe-S-P system where iron crystallizes as the first solid phase. The effects of liquid immiscibility on the evolution of the IIAB core is considered here.

The fractionation of Ir in group IIAB spans more that three orders of magnitude and is anti-correlated with Ni. The plot of log(Ir) versus log(Ni) shows a slight, upwards concave trend whereas fractionation models predict downwards concave trends. High-precision measurements by mass spectrometry of Re and Os [7] show similar ranges as Ir. The variations of Re or Os as a function of Ir form three linear segments that can be accounted for by constant distribution coefficients. This led [7] to argue for 'open system' fractionation, i.e. the addition of an unfractionated liquid or solid from an otherwise isolated reservoir, for example the silicate mantle. A similar model has previously been considered by [3] who was able to account for the co-variations of Ir and Ni but not for other important trace elements like Ga and Ge.

Meteoritic iron is considered to represent the metal that crystallized in the parent body's core. On the other hand, meteorites representing liquid compositions are unknown. Model calculations of the fractionation in the core must therefore rely on an estimate of the initial liquid composition. The initial liquid content of most elements can be estimated from the distribution coefficients and the elemental composition of the low-Ni, high-Ir members of a meteorite group. For S, both the distribution coefficient and the concentration in the metal are too poorly known. The initial S content is usually estimated by varying S to get an optimal fit for a pair of elements, for example Ir versus Au, which are most sensitive to variations in the S content. An inherent assumption, in this type of S estimate is that the initial liquid is homogeneous.

The initial liquid for group IIAB was estimated to contain 17 wt% S and 0.9 wt% P [1]. The important point about this estimate is that this composition lies well within the liquid immiscibility field in the Fe-S-P system [6]. Our estimate based on a more recent distribution coefficient model [8] confirm this. This implies that liquid immiscibility prevailed in the core of the IIAB parent body already when the crystallization started and therefore is the estimated initial liquid composition not valid.

A numerical model, which can simulate trace element fractionation from a pair of immiscible liquids, was developed by [5] and applied to the magmatic group IIIAB iron meteorites. Unfortunately, this model does not provide an accurate estimate of the initial bulk liquid composition. When liquid immiscibility occurs in a fractionating liquid, elemental extraction between the two liquids become effective and the transfer of immiscible liquid droplets may play an important role too. This provides a number of ways to produce almost linear fractionation trends with different slopes. The fractionation from immiscible liquids can be assessed only for the elements Ni, Ga, Ge, Ir, and Au for which the influence of S and P are known [8].

The core of the IIAB parent body initially consisted of immiscible sulfide liquid and P-rich metal liquid. The two liquids were probably well separated into an outer sulfide-rich core and an inner liquid metal core when the crystallization started. The main IIAB trend is dominated by the sulfide liquid. The amount of metal liquid may have been subordinate because no iron meteorites are known with a chemical signature characteristic of the metal liquid. The linear segments observed in the IIAB trend may reflect the on-going exsolution of metal liquid, the addition of sulfide liquid exsolved from the liquid metal core as well as equilibration between the immiscible liquids. More detailed modeling of the IIAB parent body is in progress.

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